California Surface Water Treatment Alternative Filtration Technology Demonstration Report[1]

November 23, 1998

Contents

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Reviewed and Approved by SWTR Committee: R. Haberman (chair), R. Hultquist, G. Yamamoto, J. Morehouse, A. Milea, R. Sakaji, P. Gilbert-Snyder, K. Souza, G. Schott, J. Stone, P. Zhou, F. Baumann

Forward

In reviewing this document for any given technology it is important to review the entire section pertaining to the technology to ensure that all conditions pertinent to the technology are applied. One should not rely solely on Table 1 or the individual summary tables that precede the narrative discussion of each technology to provide adequate material for permit provisions. The intent of providing the narrative sections was to supply field staff with sufficient material so that site specific permit provisions could be written to ensure reliable operation of the alternative technology at any given site. When the conditions of testing do not match site specific water quality parameters, it may be appropriate for the field engineer to require additional pilot testing.

A. Introduction

The filtration technologies presented herein have completed a demonstration of filtration effectiveness to satisfy a requirement of the California Surface Water Treatment Rule (CCR, Title 22, Chapter 17, Section 64650 et seq.)(CSWTR), specifically Section 64653(f) dealing with alternative filtration technologies. The demonstration studies were designed and conducted in accord with the California Department of Health Services, Division of Drinking Water and Environmental Management, Drinking Water Program, (DWP).

> "Section 64653(f) An alternative to the filtration technologies specified in subsection (a) may be used provided that the supplier demonstrates to the Department that the alternative technology provides a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal for suppliers serving more than 500 persons, or 90 percent *Giardia* cyst removal for suppliers serving 500 or fewer persons and meets the turbidity performance standards established in subsection (d). The demonstration shall be based on the results from a prior equivalency demonstration or a testing of a full scale installation that is treating a water with similar characteristics and is exposed to similar hazards as the water proposed for treatment. A pilot plant test of the water to be treated may also be used for this demonstration if conducted with the approval of the Department. The demonstration shall be presented in an engineering report prepared by a qualified engineer."

B. Appropriate Permit Provisions

The CSWTR specifies certain requirements only for the four recognized conventional filtration technologies. For alternatives to these technologies, technology specific requirements are set in the individual water supply permit. Examples of appropriate permit provisions, addressing all performance standard related issues in the CSWTR that do not apply to alternative technologies follow, with the numerical component given as an alphanumeric variable. The values can be found in the technology summary provided in Table 1.

Section 64653(c) equivalent for these technologies

The turbidity level of the filtered water shall be equal to or less than **A** NTU in 95 percent of the measurements taken each month and shall not exceed **B** NTU at any time.

When using a grab sampling monitoring program the turbidity level of the filtered water shall not exceed **C** NTU in more than two samples taken consecutively while the plant is in operation. When using a continuous monitoring program the turbidity level of the filtered water shall not exceed **C** NTU for more than eight consecutive hours while the plant is in operation.

Section 64660(b)(6) equivalent for these technologies

When any individual filter is placed back into service the filtered water turbidity of the effluent from that filter shall not exceed any of the following:

(a) **D** NTU.

(b) **E** NTU in at least 90 percent of the interruption events during any consecutive 12-month period.

(c) **A** NTU after the filter has been in operation for 4 hours.

Section 64655(b) and (d) equivalent for these technologies

To determine compliance with the turbidity performance standards specified, the turbidity level of representative samples of the combined filter effluent, prior to clearwell storage, shall be determined at least once every **four** hours that the system is in operation. Small water systems may demonstrate compliance by collecting grab samples once per day provided the system has been properly evaluated after installation and it has been documented that the daily sample is representative of system operation. Monitoring shall be conducted in accord with the operation plan.

Section 64663(a & b) equivalent for these technologies

The supplier shall notify the Department within 24 hours by telephone whenever: a) the turbidity of the combined filter effluent exceeds **B** NTU at any time; or b) more than two consecutive turbidity samples of the combined filter effluent taken every four hours exceed **C** NTU.

Table 1. Alternative Filtration Technology Specific Requirments for Water Supply Permits.

Alternative Filtration Technology	A	B	C	D	E
Conventional	0.5	5.0	1.0	2.0	1.0
Slow Sand	1.0	5.0	1.0		
Memcor Continuous Microfiltration	0.2	5.0	1.0	2.0	na
Advent Membrane System	0.2	2.0	1.0	na	na
Desal DK-5	0.2	2.0	1.0	na	na
EPD Alternative Filtration Technology	0.2	5.0	1.0	2.0	1.0
Trident, Pacer II, Advent Package Water Treatment System for 2-log *Giardia* and 1-log virus removal	0.5	5.0	1.0	2.0	1.0
Trident, Pacer II, Advent Package Water Treatment System for 2.5-log *Giardia* and 2-log virus removal	0.2	5.0	1.0	2.0	1.0
Multitech	0.5	5.0	1.0	2.0	1.0
Sverdrup/Serck Baker Hi-Rate Pressure Filtration Drinking Water Plant	0.2	1.0	0.5	1.0	0.5
Model ELB-921	0.2	1.0	0.5	1.0	na
Rosedale Bag Filtration System	0.2	1.0	0.5	1.0	na
3M Bag and Cartridge Filtration	0.2	0.5	0.2	0.5	
3M Bag and Cartridge Filtration for systems serving less than 500	0.2	1.0	0.2	0.5	

C. Technology Summary Sheets and Discussion of Demonstration Results

1. Memcor Microfiltration (Richard Sakaji)

Product: Company: Contact:	**Memcor Continuous Microfiltration** Memtec America Corp. Misco Mike Tooley (925) 225-1900 (925) 225-9200 FAX
Technology:	microfiltration, polypropylene hollow fiber, transverse flow,
Study at:	Metropolitan Water Dist. of So. Calif., San Jose WC
By:	Metropolitan Water Dist. of So. Calif., San Jose WC, AWWARF
Systems using:	MWD of SC, SJWC, several others
Raw Source:	Colorado River Aqueduct, others
	The turbidity typically ranged from 0.5 to 20 NTU.
Removal Credit:	3 log *Giardia*, **0.5 log virus removal**[+], AWWARF study tentatively shows >3 log Cryptosporidium removal.
Performance Std:	A=0.2 NTU, to be met 95% of time
	B = 5.0, C = 1.0, D = 2.0, E = n/a
Operation criteria:	**maximum flux ≤110 Lph/m^2 (0.5 gpm/m^2)** **transmembrane pressure ≤ 15 psi**
Design criteria:	
Operation plan:	establish air integrity test frequency
Study:	

[+] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must *demonstrate* that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. A 1.5 log removal of virus was demonstrated, but due to uncertainties in methods and test protocols a 1 log safety factor was applied to the log virus removal credit giving the technology a 0.5 log virus removal credit. The balance of the removal/inactivation can be achieved by disinfection. In order for this technology to be used in systems serving more than 500 persons the 90 percent virus removal requirement must be waived and the supplier must, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

Product: Company: Contact:	**Memcor Microfiltration** Memtec America Corp. (U.S. Filter) Misco Mike Tooley (925) 225-1900 (925) 225-9200 FAX
Technology:	microfiltration, polypropylene hollow fiber, transverse flow
Study at:	Carmichael Water District, San Jose Water Co.
By:	San Jose Water Co., Montgomery-Watson for Carmichael Water District
Systems using:	Carmichael Water District, San Jose Water Co.
Raw Source:	American River, SJWC Creek
Removal Credit:	3 log *Giardia*, **0 log virus removal**[+]
Performance Std:	A=0.2 NTU, to be met 95% of time
	B = 5.0, C = 1.0, D = 2.0, E = n/a
Operation criteria:	**maximum flux ≤160 Lph/m^2 (0.7 gpm/m^2)** **trans membrane pressure ≤17 psi**
Design criteria:	
Operation plan:	establish air integrity test frequency
Study:	

[+] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. In order for this technology to be used in systems serving more than 500 persons, the 90 percent virus removal requirement must be waived and the supplier must, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

Approval given on ** (SWTR Committee meeting minutes)

The initial approval for the Memcor microfiltration technology was based on the Metropolitan Water District of Southern California's study conducted for their Desert Pumping Plants (Coffey 1992) using Colorado River water. These studies were conducted using a maximum flux of 110 Lph/m^2 (0.50 gpm/m^2) and introduced a coagulant into the feed stream for the evaluation of organics removal. No coagulant was added during the pathogen seeding studies. In addition to the 3-log *Giardia* removal credit, the transmembrane pressure (TMP) was limited to 15 psig, as the TMP in the studies did not exceed 15 psig.

MWDSC (Coffey 1992) conducted virus (MS2 bacteriophage) and *Giardia* challenge studies to demonstrate the efficacy of this process for removing these pathogens. These studies showed a consistent >4.4-log removal of *Giardia* (n=3). The three virus seeding runs conducted on the pilot plant showed log removals that ranged from 1.65 to 2.87 (average = 2.16). Since the technology of conducting pathogen spiking studies was still evolving in 1992, there were questions about the variability of the performance of these membranes. In addition there were analytical questions (recovery, accuracy, and

precision) that were not sufficiently addressed. This resulted in the Department imposing a 0.5-log credit for virus removal on the microfilration membranes. In addition, a 3-log removal credit was granted for *Giardia* removal.

Recent studies (Carmichael Water District and San Jose Water Co.) were used to grant an increased flux to this alternative technology (Sakaji 1998). The Memcor microfiltration technology can be used at a flux of 160 Lph/m^2 (0.7 gpm/m^2) and transmembrane pressure of 17 psig. However, at this flux, the technology has been granted a 3-log *Giardia* removal credit and 0-log virus removal credit and can only be used on surface waters certified to have a watershed that is free of a virus hazard or in systems serving less than 500 service connections. The increased flux for the Memcor microfiltration technology was approved by the SWTR committee on April 30, 1998 and approved by Exceutive Staff on July 28, 1998.

Membrane Integrity.

As long as the membrane remains intact, the performance of the membrane as a physical barrier to pathogens is not in question. However, any breech in the integrity of the membrane can allow the passage of pathogens through the membrane as holes or broken membranes may allow particulates to follow the path of least resistance. Therefore, the system operator must detail a monitoring program that will ensure the integrity of the membranes and membrane unit.

The importance of a moitoring system to ensure membrane integrity is critical to ensuring the integrity of the treatment barrier. Since viruses are about 0.027 μm in diameter, viable viruses could be passed through holes greater than 0.03 μm in the membrane. The manufacturer's pore cutoff is reported to be one order of magnitude greater (0.2 μm) than a viron or virus particle. Using a fluorescent rejection technique, Jacangelo et al. (1997) report that the 90% rejection pore size is 0.22 μm and the 95% rejection point is reached at 0.37 μm.

From a physical standpoint and based on the fluorescent sphere rejection work done by Janangelo et. al., intact membranes should reject the cysts and oocysts of *Giardia* and *Cryptosporidium*, which, although not exactly spherical in shape, are an order of magnitude larger.

Generally the operatonal TMP is restricted to documented conditions of operation. TMP is analogous to headloss in conventional filtration. However, the operating theory behind conventional filters differs from that of membrane filtration. Unlike depth filtration which relies on collector mechanisms that require particulate and filter media interaction, membrane filters restrict passage of particulates primarily by sieving or size exclusion. It is recognized that the TMP increases as the membranes foul, due to the formation of a surface layer on the membrane. This surface layer can reduce the effective pore size of the membrane thereby improving particulate removal. However, during a period immediately after backwashing or chemical cleaning the fouling layer on the membrane has been removed and particulates, including some pathogens, can pass through the membranes.

Concerns that increased TMP may lead to premature breakthrough of this membrane by pushing pathogens through the membrane have been raised. Unlike colloids that have some rigidity to their structure, the elastic membrane (protein coat) of pathogens allows them to be reshaped so that they can squeezed through holes smaller than their actual physical size. As shown in Figure 1-1 the log removal from the virus seeding studies drops when the TMP exceeds 17 psi (the presently allowed TMP for a flux of 160 Lph/m^2). It is not possible to evaluate fully the impact of the increased TMP on the membrane performance since this is only a single data point and from a review of the report there is no indication of the fouling state of the membrane when this data point was collected. Since operation of the membrane at TMPs up to 17 psi is coupled with particle counting information, this would seem to provide a reasonable indication that membrane performance has not been compromised. The operation of the unit was restricted to below 17 psi until additional studies are conducted.

Filter Backwash. The backwash from the Memcor microfiltration process can be returned to the headworks of the filtration plant for recycling. The backwash recycle flow should not exceed 10% of the total flow into the treatment plant. All other backwash recycle criteria apply (see *Cryptosporidium* Action Plan, Appendix K of the California SWTR Guidance Manual, Ten States Standards (1997), and Partnership for Safe Water Documents for additional guidance).

Membrane Cleaner (chemical). The chemical cleaner used for this process can be recycled and reused, if the manufacturers instructions are followed. The rinse water from the chemical cleaning procedure should be disposed of, but not recycled.

The Memclean chemical cleaning agent has been certified by NSF under their standard 61 (Johnson 1998). The NSF certification is based on the manufacturer's claims, that were subsequently confirmed by the testing required for NSF standard 61 listing.

There have been questions raised regarding the adequacy of the rinsing operation. Under the NSF certification procedure pH was used to indicate when the cleaning agent had been flushed from the system so it could be returned to service. However, there was no correlation established between the concentration of surfactant and the pH. As the alkalinity or buffering capacity of the rinse water can impact the pH readings, residual surfactant and cleaning chemicals can continue to bleed out of the filtration system even after the manufacturer's recommended "return to service" pH levels had been reached.

At present, the presence of foaming or surface active agents, as measured by Methylene Blue Active Substances (MBAS), is covered by a secondary standard (aesthetic). However, the MBAS test only covers cationic surfactants. Since the memclean solution is a nonionic surfactant, the MBAS test is not appropriate to use for determining surfactant residuals in the rinse water. There are no simple field tests for anionic or nonionic surfactants at present although other types of analytical methods are available.

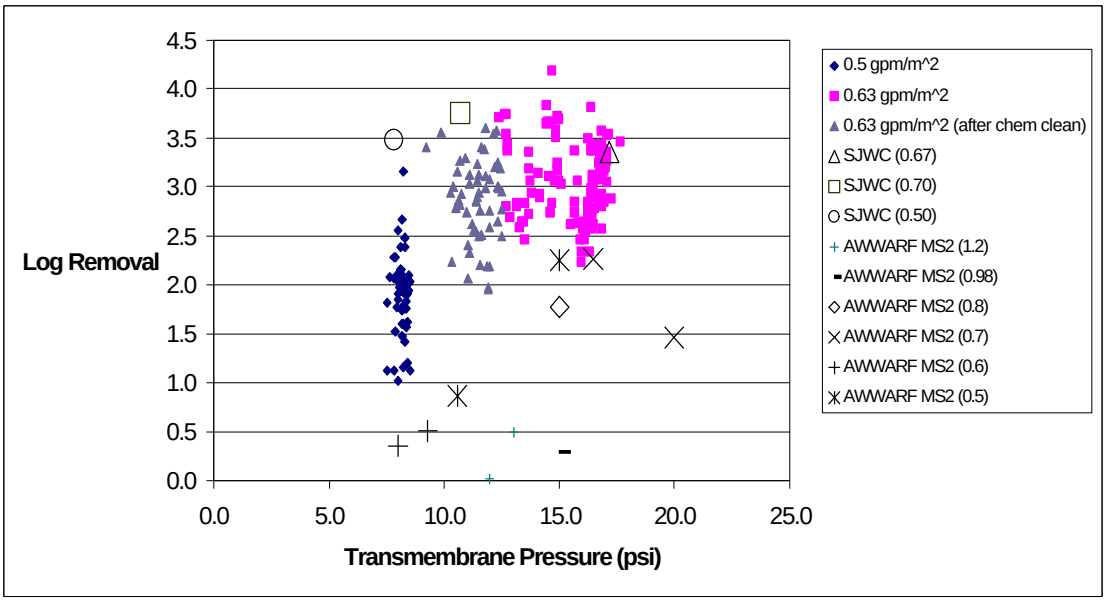

Figure 1-1. Transmembrane Pressure and Log Removal for Particle and MS2 seeding studies. Flux rates in parentheses are given in mixed english and metric units of gpm/m^2, as reported in Jacangelo *et al*. (1997).

References

Coffey, B.

"Conceptual Design Report for Desert Pumping Plant Domestic Water Systems," Metropolitan Water District of Southern California, September **1992**.

Jacangelo, J.G.; Adham, S.; Laine, J-M.

"Membrane Filtration for Microbial Removal," Report No. 90715, American Water Works Association Research Foundation, Denver, CO February 1997.

Johnson, P.

Memclean study results, U.S. Filter/Memcor letter, June 11, 1998.

Sakaji, R.

"Amend Flux and Transmembrane Pressure Criteria for Memcor Microfiltration Alternative Technology," California Department of Health Services Memo, dated May 8, 1998.

2. Aquasource Ultrafiltration (Richard Sakaji)

Product: Company: Contact:	**Advent Membrane System** Aquasource North America, LLC Michael A. Dimitriou (804) 672-8160 FAX: (804) 756-7600 2924 Emerywood Pkwy PO Box 70295 Richmond, VA 23255-0295
Technology:	ultrafiltration, cellulosic esters hollow fiber, crossflow, membrane manufactured by Lyonnaise Des Eaux
Study at:	East Bay MUD, Contra Costa WD
By:	AWWARF, East Bay MUD, Contra Costa WD, Montgomery-Watson
Systems using:	Pardee Recreational Area (East Bay MUD)
Raw Source used in testing:	Mokuelumne R. and Delta
	The source water alkalinity ranges from__to__mg/L as $CaCO_3$ and the temperature from__to__°C. The turbidity typically ranged from__to__NTU. __filter run was spiked to__NTU
Removal Credit:	3-log *Giardia*, 4-log virus removal
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B = 2.0, C = 1.0, D = n/a, E = n/a
Operation criteria:	1. 29 psi maximum transmembrane pressure and 0.97 Lph/m^2 (0.046 gpm/ft^2) flux. 2. Particle monitor set to terminate run at a count of 500 units 3. Backwash when transmembrane pressure reaches 22 psi in recirculation filtration mode and 18 psi when operating in dead-end filtration mode 4. Backwash once every three hours 5. Clean membranes using manufacturers instructions once every six months 6. Operate in deadend mode for raw water turbidities up to 1 NTU, in recirculation mode without a bleed to waste for raw water turbidities up to 5 NTU, and in recirculation mode with a bleed to waste when raw water turbidities exceed 5 NTU.
Design criteria:	
Operation plan:	
Study:	

The approval to use this alternative technology to meet the SWTR requirements was given on ** (SWTR Committee meeting minutes)

The reported (James M. Montgomery et al. 1991) particle removals (geometric mean) for *Giardia* size particles (7-14 μm) were reported to be on the order of 3.1 log (81 particles/mL in the Mokelumne source water to 0.06 particles/mL in the permeate) and 3.6 log (194 particles/mL in the Delta source water to <0.04 particles/mL in the permeate) Slightly better log removals on the same source waters were reported for particles in the *Cryptosporidium* size range (4-7 μm). The geometric mean log removal was 3.4 for Mokelumne water (249 particles/mL in source water and 0.10 particles/mL in the permeate) and 3.9 (512 particles/mL in the source water and 0.06 particles/mL in the permeate) for Delta water. Other source water quality parameters are listed in Table 2-1.

The UF membranes were periodically challenged with virus (MS2) over a 37 to 38 day period of time. During this period, no virus was detected in the UF permeate.

As long as the membranes remained intact no *Giardia* or viruses were detected in the permeate. The loss of membrane integrity (e.g., a single severed fiber) two logs of *Giardia* removal dropped by 2 logs and the virus removal dropped by 4 (??). For such a gross catastrophic failure, it was recommended that particle counters be used to evaluate membrane integrity.

On the basis of the James M. Montgomery report (1991) the SWTR committee granted the then Infilco-Degremont Advent UF membrane a 3-log *Giardia* and 4-log virus removal credit. Since this report was issued, additional studies using this membrane have been conducted in California and elsewhere (Jancangelo et al. 1997) confirming erlier studies and the log removal credits granted the technology have not changed.

Table 2-1. Source Water Quality (Mean values with ranges reported in parentheses).

Parameter	Mokelumne Water	Delta Water
PH	9.0 (6.8-9.5)	8.1 (7.5-9.1)
Alkalinity, mg/L as $CaCO_3$	23 (21-24)	71 (43-103)
Hardness, mg/L as $CaCO_3$	22 (20-24)	106 (52-150)
Turbidity, NTU	0.49 (0.1-2.5)	9.0 (1.9-47)
Total Organic Carbon, mg/L	1.7 (1.3-2.6)	3.6 (2.4-8.9)
Temperature, °C	17 (10-27)	17 (9-27)
Particle Density >1 μm, # $\times 10^3$/mL	5.4 (0.3-20)	111 (24-332)
Total Coliform, MPN/100mL	<2.8 (<2.2-170)	86 (2.2-1600)
HPC Bacteria, CFU/mL	141 (1-8600)	1289 (25-7500)

(Table from: James M. Montgomery et al, 1991)

Table 2-2. Lyonnaise des Eaux-Dumez (Aquasource) Ultrafiltration Specifications

	1991 (James M. Montgomery *et al*. 1991)	1997 (Jancangelo *et al*. 1997)
Configuration	Hollow fiber	Hollow fiber
Material	Cellulosic derivative	Cellulosic ester
Molecular Weight Cutoff (Daltons)	100,000	100,000
Maximum Temperature (°C)	30	35
pH Range	4-8.5	4-8.5
Maximum transmembrane pressure (psi)	29	5-29
Specific Flux (L/h/m^2/bar)	271-345	100 (20°C)
Surface Area (m^2)		Bench-scale: 0.07 (20 membranes) Pilot-scale: 7.1 (2060 membranes)

Table 2-3. Virus and Giardia Seeding Study Results (James M. Montgomery et al., 1991).

Pathogen	Delta Log Removal	Mokelumne Log Removal
Virus (MS2)	7.2 (21)[+]	7.0 (12)
Total Coliforms	7.4 (4)	7.1 (3)
Giardia	5.1 (3)	4.7 (7)

[+] number of batch tests in parentheses.

Table 2-2 summarizes the manufacturer's specifications published in 1991 and 1997. With only three exceptions, the slightly higher maximum operating temperature, lower specific flux, and the composition of the membrane, the specifications for the membrane have not changed. At present it is not known whether the term "cellulosic derivative" differs from a cellulosic ester or if they refer to the same polymeric group. The cellulosic ester can be a cellulosic derivative, but a cellulosic derivative may not necessarily be an ester.

Nevertheless the study results (Jancangelo et al. 1997) provide additional information on the effectiveness of the Aquasource membranes on specific pathogens. These further demonstrations provide additional validation of the Aquasource membrane technology. As with any membrane based technology, as long as the membranes remain intact, the Aquasource membrane will provide a strong physical barrier that prevents the passage of pathogens into the permeate.

We do not have log removals based on the 95th percentile from the Jacangelo *et. al.* study, but the pathogen seeding challenges conducted in the 1997 study were conducted with freshly cleaned (chemical) or new membrane modules. Since previous studies have led us to believe that a clean membrane surface is one of the times when the membrane barrier can be compromised, the log removals reported in Table 2-4 should be fairly indicative of membrane performance during its most vulnerable period of operation. Therefore, it

would be reasonable to assume that the log removal performances listed in Table 2-4 should easily occur at least 95 percent of the time. However, due to uncertainties with the experimental protocols and apparent absence of controls, the previous credit granted the process will not be changed.

With the exception of the *Giardia* removal results, the seeding studies conducted in 1997 were very similar to those achieved in 1991. The higher log removals reported in the 1997 report are probably due to improvements in the techniques used to spike or seed the pathogens into the source water. This work was conducted on several source waters, all of which were outside California except the San Jose Water Company Lake Elsman supply (water quality data reported in Table 2-5).

This study also examined the effect of pH on virus removal and found none. Virus removals during filter runs conducted at a pH or 5 and 9 showed no significant difference in performance over runs conducted at ambient pH.

Membrane testing in 1997 (Jacangelo et al.) examined the particle exclusion characteristics of the Aquasource membrane. The manufacturer reports a 100,000 Dalton[2] molecular weight cutoff. The study results showed a 90% rejection of dextran at 160,000 Daltons (3 psi). Although this result indicates the distributuion of pore sizes may be wider than the nominal pore size reported by the manufacturer (100,000 Daltons), it may be an sartifact of the testing procedure used to determine the pore size distribution (no standard). This may lead one to believe that the membrane may be susceptible to virus passage due to the small physical size of viruses. Test results indicate that virus removal by an intact Aquasource UF membrane is still very good, regardless even when the membrane surface is clean.

[2] A Dalton is a unit of mass. Therefore, no direct relationship exists between a linear measure of size and the molecular weight. While the molecular weight cut-off may provide a general indication of size, it does so in mass units. However, a 0.01 μm pore size might roughly correspond to a molecular weight cutoff of 100,000 Daltons.

Table 2-4. Aquasource Pathogen Seeding Study Results (Jacangelo et al. 1997)

Pathogen	N	Log Removal	
Heterotrophic Plate Count	12	140 to 2.1 /mL	Pilot
MS2	4	>6.9	Bench, pH 7.9, turbidity 3 NTU , new module
Giardia	3	>7.0	Pilot
Cryptosporidium	3	>6.7	Pilot

Table 2-5. Lake Elsman Water Quality Summary (Jacangelo et al. 1997)

Water Quality Parameter	Average	Range
Turbidity	3.4	0.3-100
PH	7.9	7.1-10
Temperature (°C)	13	7-23
Alkalinity (mg/L as $CaCO_3$)	140	84-194
Hardness (mg/L as $CaCO_3$)	160	92-234
TOC (mg/L)	2.6	1.5-6.8
UV254	0.06	0.03-0.25
Color	5	2-25
HPC	1885	270-12,000
Total Coliforms (MPN/100mL)	13	1-460

References

James M. Montgomery Consulting Engineers, Inc., Lyonnaise Des Eaux-Dumez

"Pilot Investigation of Membrane Technology for Particulate Removal in Drinking Water Treatment," James M. Montgomery Consulting Engineers, Inc., Pasadena, CA, February **1991**.

Jacangelo, J.G.; Patania, N.L.; Laine, J-.M.; Booe, W.; Mallevialle, J.; General Waterworks Management and Service Co.

"Low Pressure Membrane Filtration for Particle Removal," AWWA Rsearch Foundation, Denver, CO, **1992**.

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"Membrane Filtration for Microbial Removal," Report No. 90715, American Water Works Association Research Foundation, Denver, CO February 1997.

3. DESAL DK-5 Thin Film Nanofiltration Membrane (Bob Hultquist and modified by Rick Sakaji)

Product: Company: Contact: Product: Company: Contact: Product: Company: Contact: Product: Company: Contact:	Systems using **"Desal DK-5"** membrane, i.e., any well designed and constructed treatment system using this membrane Mem-Clear American Water Technologies[3] Paul Chapman, (209) 983-9800 Mem-Brain™ Waste Water Management Int'l. Bert Baker, (209) 277-1475 H Series ATP Manufacturing (California Sales) 479 Mason St., Suite 221D Vacaville, CA 95687 Mark Clausen, (707) 447-5076 or ATP Manufacturing Unit 1 attn: Ernie Mee or Bud Haney 2595 McGillivray Blvd Winnipeg, Manitoba CN R3Y1J5 (204) 888-2292 Eagle Environmental Technologies Ltd. PO Box 999 Angels Camp, CA 95222 Jerry Wilmot (209) 736-4530
Technology:	Nanofiltration, spiral wound
Study at:	Solano Irrigation District
By:	Summers Engineering
Systems using:	Marconi Conference Center
Raw Source (Study):	Putah South Canal. The source water turbidity typically ranged from 8 to 15 NTU. Two filter runs were spiked to 150+.
Removal Credit:	3-log *Giardia*, 2-log virus removal for all sources *Cryptosporidium* oocyst challenge demonstrated >5-log

[3] Attempts to contact this company in August 1998 have not been succesful. Their phone number listed above has been disconnected and no alternative number was given. Unless the manufacturer contacts the Department before the next edition of this report is produced, this company listing will be deleted.

	removal
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B = 2.0, C = 1.0, D = na, E = na
Operation criteria:	
Design criteria:	
Operation plan:	
Study:	

Approval given in November 9, 1995 SWTR committee minutes.

American Water Technologies Inc. and Waste Water Management International Inc., using a filtration system provided by Waterite Inc. (now ATP Manufacturing Ltd.) that incorporates a DESAL DK-5 membrane element completed a demonstration. The filtration technology tested consisted of a Desalination Systems Inc. DESAL DK-5 thin film nanofiltration element as part of a complete filtration system.

The demonstration was conducted on the Putah South Canal source of Solano Irrigation District. The source water turbidity usually ranged from 8 to 15 NTU during the study. The turbidity was artificially increased to 150+ NTU using native sediment for two short runs. The demonstration was made using particle counts, turbidity, and a virus challenge. The test protocol and performance of the filtration system is documented in a report from American Water Technologies and Waste Water Management International dated February 7, 1994. The demonstration study was intended to evaluate the suitability of the technology for point of entry treatment. This report only deals with the filtration technology approval issue.

The filtration system successfully demonstrated the ability to reliably achieve a 99.9% (3-log) *Giardia* cyst removal and 99% (2-log) virus removal. A Cryptosporidium oocyst challenge demonstrated a >99.999% removal. The filtration system was able to comply with a 0.5 NTU turbidity performance standard in at least 95% of all measurements made over the length of a filter run. The effluent turbidity was reliably below 0.2 NTU when measured by grab sample. Continuous turbidimeter measurements often ranged up to 0.5 NTU, presumably due to air bubbles. The effluent turbidity did not appear to vary with raw water turbidity or operational conditions.

The DESAL DK-5 membrane element successfully demonstrated that it could achieve the required organism removals while reliably producing an effluent with a turbidity of 0.2 NTU. It is not known whether a DESAL DK-5 membrane filtration system would meet the same organism removal efficiencies while producing a higher turbidity effluent.

The filtration system must be designed and operated in conformance with the Desalination Systems, Inc. recommendations for the DESAL-5 membrane except those regarding formaldehyde (see below).

The design of a filtration system using the DESAL DK-5 must include an element containment vessel that will provide a tight seal with the DESAL element over the expected range of operating pressures. A Payne Mfg. Co. vessel was used in the demonstrated device and is satisfactory. The system design must provide instrumentation and control features to regulate the recirculation rate and fast flush cycles. Sample taps must be provided for raw water and permeate monitoring. There must be provision in the design for verifying that the membrane element in the system is a DESAL-5. The system must be designed to minimize the potential cross-connections between raw and finished water.

An operations plan for this filtration technology should address how loss of membrane integrity will be identified when raw water turbidities are low. An alarm triggered by a high particle index is acceptable. The plan must also address the frequency and method of element cleaning. The trigger for element replacement must be identified. To prevent degradation of the membrane, and resulting loss of organism removal efficiency, the operation must observe the recommended operating pH range of 4-11, the cleaning pH range of 2-11.5, and the chlorine tolerance of 2000 ppm-hours. Manufacturers recommendations regarding other oxidants must be observed.

Several documents from the DESAL Engineers Catalog: Product Specifications, DESAL-5; Bulletin E-15, Cleaning and Sanitizing; and Bulletin E-22, Cleaners/Sanitizes were attached to the original approval memo and should be used by field engineers reviewing proposals to use this technology. The manufactures Bulletin E-15 recommends flushing the membrane with a formaldehyde solution to control biological growths when reduced permeate flow or increased differential pressure indicates a problem. **Formaldehyde or solutions containing formaldehyde should not be used**. Bulletin E-15 suggests 0.1% sodium bisulfite as an option and the permit should specify use of this chemical for cleaning.

Attempts by the Department to resolve operational questions regarding the adequacy of the manufacturers chemical cleaning and flushing procedures remain unresolved at this time. The Department has not received a written study protocol or evidence to verify that the flushing procedures recommended by the manufacturer are adequate to prevent the the cleaning chemicals from entering the potable water supply. The Department has also requested information on NSF 61 certification of the cleaning chemicals with no response to date. Since the presence of surface active agents (e.g., MBAS) is handled through a secondary standard (an aesthetic standard), the lack of this information does not preclude the use of this technology to meet the SWTR requirements, at this time.

This DESAL DK-5 membrane is an acceptable filtration technology for use on any approved surface source when used as the core of a complete and well designed, constructed, and operated filtration system.

4. EPD Alternative Filtration Technology (Bob Hultquist)

Product: Company: Contact:	**EPD Alternative Filtration Technology** Environmental Products Division (EPD) of Hoffinger Industries, Rancho Cucamonga,California Michael Stockton, (800)266-4740
Technology:	in-line, high-rate, dual-stage pressure filters using 12 inches of Garnet media in each stage (d_{10} = 0.27 mm [UC = 1.7] and d_{10} = 0.18 mm [UC = 1.61]), cationic polymer coagulant.
Study at:	Yucaipa Valley Water District, 1993
By:	EPD, Dr. Hendricks, Co. St. Univ. for organism challenges
Systems using:	Yucaipa Valley Water District, Miners Oaks CWD, Banning Heights Mutual, Havasu WC
Raw Source:	The source water alkalinity ranges from 64 to 190 mg/L as $CaCO_3$ and the temperature from 9 to 15 °C. The turbidity typically ranged from 0.4 to 6 NTU. One filter run was spiked to 21 NTU
Removal Credit:	2-log *Giardia*, 1-log virus removal Two *Cryptosporidium* oocyst challenges demonstrate oocyst removal efficiencies comparable to *Giardia* cyst removal.
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B = 5.0, C = 1.0, D = 2.0, E = 1.0
Operation criteria:	• treat up to 6 NTU at 12 gpm/ft^2 • treat up to 20 NTU at 5 gpm/ft^2
Design criteria:	filter-to-waste required
Operation plan:	• identify best coagulant for source • backwash at 14 psi headloss
Study:	

The filtration technology tested consisted of in-line, high rate, dual stage, pressure filters using 12 inches of Garnet media in each stage (d_{10} = 0.27 mm [UC = 1.7] and d_{10} = 0.18 mm [UC = 1.61]), and a General Chemical CLARION A410P cationic polymer coagulant. The coagulant feed and filter-to-waste valves were automatically controlled by raw and filtered water continuously reading turbidimeters.

The demonstration was conducted on the Oak Glen source of Yucaipa Valley Water District, Yucaipa, California (Hendricks 1993; Bowman *et. al.* 1993). The source water alkalinity ranges from 164 to 190 mg/L as $CaCO_3$ and the temperature from 9 to 15 °C. The turbidity typically ranged from 0.4 to 6 NTU. One filter run was spiked to 21 NTU. The demonstration was made using *Giardia* lamblia cyst, Cryptosporidium parvum oocyst, and MS-2 coliphage virus challenges, and particle counts.

The filtration system successfully demonstrated the ability to reliably achieve a 99% (2-log) *Giardia* cyst removal and 90% (1-log) virus removal. Two Cryptosporidium oocyst challenges demonstrate oocyst removal efficiencies comparable to *Giardia* cyst removal. The filtration system was also able to produce an effluent with less than 0.5 NTU in at least 95% of all measurements made over the length of a filter run. This demonstration was performed with hydraulic loading rates up to 12 gpm/sq ft. Increasing the rate to this level did not noticeably degrade performance with this raw water at a turbidity of 6 NTU. There is data to show that turbidities of 20 NTU can be adequately treated at 5 gpm/sq ft. The filters did meet the required filtration efficiencies in two filter runs without the addition of a coagulant, but the data is insufficient to authorize coagulant free operation. It was shown that the use of a coagulant significantly enhanced particle removal efficiency. The use of a cationic polymer either pre-first stage or pre-second stage was shown to be effective. Backwash was usually initiated at a head loss of 14 psi. Filter to waste was utilized to meet the turbidity requirements after backwash.

The EPD technology successfully demonstrated that it could achieve the required organism removals while reliably producing an effluent with a turbidity of 0.2 NTU. It is not known whether the EPD filtration system would meet the same organism removal efficiencies while producing a higher turbidity effluent.

The EPD filtration system is an acceptable filtration technology for the Oak Glen source at Yucaipa Valley Water District and other sources with similar water quality and treatability characteristics. Coagulant chemical and dose should be optimized for each application. Hydraulic loading rates up to 12 gpm/sq ft may be acceptable when it is demonstrated that the turbidity performance standard will be met. The direct filtration performance, design, reliability, and operation (with the exception of loading rate) requirements of the Surface Water Filtration and Disinfection regulation are appropriate to this technology.

References

Hendricks, D.; Boutros, S.; Sobsey, M.

"Particle Removal Performance of the EPD Hi-Rate Filtration System" August **1993**.

Bowman, G.

"EPD Drinking Water Filtration Plant, an Alternative Filtration Technology Demonstration Study" August **1993**.

5. Contact Clarification/Filtration (Bob Hultquist)

Product: Company: Contact:	**Trident** Microfloc Mike Brunell, (916) 939-0728
Product: Company: Contact:	**Pacer II** Roberts Filter Co. Lee Roberts (215)583-3131
Product: Company: Contact:	**Advent Package Water Treatment System** Infilco Degremont Inc. Rick Jaccarino, (804) 756-7600
Technology:	contact clarification/filtration
Study at:	numerous in U.S.
By:	
Systems using:	numerous
Raw Source:	The source water alkalinity ranges from__to__ mg/L as $CaCO_3$ and the temperature from__to__°F. The turbidity typically ranged to 15 NTU.
Removal Credit:	2-log *Giardia*, 1-log virus removal for all sources where direct filtration would be a suitable technology; 2.5-log *Giardia*, 2-log virus removal for some sources/operational criteria
Performance Std:	A = 0.5 NTU for 2/1-log removal, A = 0.2 NTU for 2.5/2-log removal, to be met 95% of the time B = 5.0, C = 1.0, D = 2.0, E = 1.0
Operation criteria:	Same as for conventional or direct filtration technology.
Design criteria:	Same as for conventional or direct filtration technology.
Operation plan:	Same as for conventional or direct filtration technology.
Study:	

Multitech

Product: Company: Contact:	**Multitech** Culligan USA (U.S. Filter) Dr. Frank Brigano, (708) 205-5964
Technology:	contact clarification/filtration
Study at:	Freestone, others in U.S.
By:	
Systems using:	Freestone, June Lake
Raw Source:	The source water alkalinity ranges from_to_mg/L as $CaCO_3$ and the temperature from_to_°C. The turbidity typically ranged from_to_NTU. _filter run was spiked to_NTU
Removal Credit:	2-log *Giardia*, 1-log virus removal for all sources where direct filtration would be a suitable technology
Performance Std:	A= 0.5 NTU, to be met 95% of time
	B = 5.0, C = 1.0, D = 2.0, E = 1.0
Operation criteria:	Same as for direct filtration technology.
Design criteria:	Same as for direct filtration technology.
Operation plan:	Same as for direct filtration technology.
Study:	

There are several companies marketing a filtration technology that consists of a coarse media bed, providing some flocculation and solids removal, followed by a filter. This filtration technology is not among the recognized technologies identified in the Surface Water Filtration and Disinfection regulations. The technology does not qualify as direct filtration because it does not provide flocculation comparable to that defined by accepted industry design criteria (AWWA/ASCE Water Treatment Plant Design , Ten States Recommended Standards for Water Works, and water treatment process design text books). The filtration technology must, therefore, be authorized for use by a public water system according to the process established in SWF&DR Section 64653(f), (g), (h), and (i). The DHS Drinking Water Program (DWP) has adopted the term contact clarification/filtration to identify this technology

The DHS Drinking Water Program (DWP) has adopted the term contact clarification - filtration to identify this technology. A contact clarifier is a bed of granular fine to medium gravel sized media. The bed is preceded by coagulant addition and high energy mixing. Flocculation and solids retention occurs within the bed. The bed is periodically washed to waste by maintaining hydraulic flow or backwashing while applying a vigorous air scour. The wash should be triggered by excessive head loss, effluent turbidity, or length of run. The filter accompanying the contact clarifier should conform with accepted industry filter design criteria.

Contact clarification/filtration systems having demonstrated effective filtration through studies may be approved without further study on all waters where the median total

coliform MPN is less than 500 per 100 mL and the turbidity is less than 15 NTU (where direct filtration is appropriate according to the USEPA and California surface water treatment guidance manuals). Additional pilot plant studies should not be necessary except to ascertain the ability to deal with source specific water quality problems and identify the best coagulant and optimum dose.

A substantial number of particle count and organism challenge studies have been completed with treatment systems designed in conformance with this technology. The studies demonstrate that the technology, as executed by the specific systems involved in the studies, meets the removal efficiency and effluent turbidity requirements of Section 64653(f). These system can, therefore, be readily approved for use on a variety of sources. Other companies with similar systems must provide evidence of compliance with Section 64653(f).

The only systems known to qualify for approval at this time are the Microfloc Trident, Roberts Pacer II, Infilco Degremont Advent Package Water Treatment System, and Culligan Multi-Tech. These systems should be granted credit for 2-log *Giardia* cysts and 1-log virus removal when operated in compliance with a performance standard of 0.5 NTU in the effluent 95% of the time; in conformance with the performance, monitoring, design, reliability, and operational requirements appropriate to direct filtration; and the plant operations plan. As with any alternative filtration technology the performance standards, performance standard monitoring schedule, requirements for Department notification in the case of performance standard violation, and operating criteria must be stated in permit provisions.

Higher Removal Credit

The filtration technology as implemented by Microfloc, Roberts, and Infilco Degremont has successfully demonstrated organism and/or particle removal performance equivalent to that achieved by conventional treatment on waters with turbidities as shown in the Table 5-1 for various combinations of temperature and alkalinity. For these conditions you may allow a credit of 2.5-log *Giardia* cyst removal and 2.0-log virus removal when operated in compliance with a performance standard of 0.2 NTU in the effluent 95% of the time. The other requirements are as stated for the previous situation except that the appropriate turbidity limit after the filter has been in operation for four hours is 0.2 NTU.

Table 5-1. Successfully Treated Raw Water Turbidities

Temp. (°F)	Alkalinity as $CaCO_3$ (mg/L)								
	70	80	90	100	110	120	130	140	170
30				10-20					
40									
50	1								
60			2-20			1-40		20-130	1
70			2	30-70	30-70				
80		20-30	20-30						

Cautions

Some of the floating contact clarifier media used by the Trident systems at Fort Bragg and Willits has become coated to the degree that the media is no longer buoyant. There is some loss of contact clarifier effectiveness in this situation. The condition appears to be a possibility where the water is high in iron or manganese, or potassium permanganate is fed. Washing or replacement of the media has been necessary.

In 1997, the raw source turbidity for the Folsom Prison's Microfloc direct filtration system reached 250-300 NTU (Morehouse 1997). The system could not operate effectively at this high turbidity and the plant was shutdown. A temporary interconnection between the prison and local water system was setup to provide water (two fire engine pumper trucks providing system pressure between fire hydrants located in the respective systems). Bottle water, limited showers, and portable toilets were being used to limit water use.

References

Morehouse, J.

personal communication, Janaury 4, 1997.

6. Sverdrup/Serck Baker Hi-Rate Pressure Filtration Drinking Water Plant

Product: Company: Contact:	**Sverdrup/Serck Baker Hi-Rate Pressure Filtration Drinking Water Plant** Serck Baker Inc. Houston, Texas Tim Trapani, (713) 586-8400
Technology:	in-line, high rate pressure filters using: 18" top layer of 0.85 mm Anthracite (UC 1.7), 18" middle layer of 0.35 mm garnet (UC 1.32), 13" support layer of 1.45 mm garnet (UC 1.23), air scour.
Study at:	Casitas Municipal Water District, 1995
By:	Sverdrup Civil Inc., Dr. Gerba, U. of Arizona
Systems using:	Casitas Municipal Water District
Raw Source:	The source water alkalinity ranges from 130 to 160 mg/L as $CaCO_3$ and the temperature from 14 to 18°C. The turbidity typically ranged from 0.8 to 3.0 NTU. One filter run was spiked to 8.6 NTU.
Removal Credit:	2-log *Giardia*, 1-log virus removal
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B = 1.0, C = 0.5, D = 1.0, E = 0.5
Operation criteria:	treat up to 9 NTU at 12 gpm/ft^2
Design criteria:	filter-to-waste required
Operation plan:	• prechlorination • identify best coagulant for source • backwash at 15 psi headloss
Required at Casitas:	• ferric sulfate and polymer required for 1-log virus removal • all filters must be in service if the rate through any filter exceeds 6 gpm/ft^2 • NTU (95% of time) and 2-log removal in 5-15 μm particle size performance goals • streaming current detector to control coagulant dose • full treatment (coagulation, flocculation, sedimentation, and filtration) of all recycled backwash water • Recycled backwash returns to the head of the plant

7. U.S. Filter Model ELB-921 (Bob Hultquist)

Product: Company: Contact:	**Model ELB-921** U.S. Filter Municipal Division David Ball Ames, IA (515) 232-4121
Technology:	a prefilter (Memtec 1 µm poly cartridge filter - Filterite "1U30U"), followed by a primary *Giardia* barrier (3M Model 523 bag filter* with U.S. Filter Permaseal), integrated into package plant, granular media prefilter is necessary when source water turbidities exceed 1 NTU.
Study at:	Fern Valley Water District
By:	
Systems using:	Fern Valley
Raw Source:	Low turbidity (< one NTU), protected (minimal virus hazard) The source water alkalinity ranges from13 to 25 mg/L as $CaCO_3$ and the temperature from 8 to 11°C. The turbidity typically ranged from 0.054 to 0.634 NTU. No spiked filter run.
Removal Credit:	2.0-log *Giardia*, 0-log virus removal+
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B = 1.0, C = 0.5, D = 1.0, E = na
Operation criteria:	
Design criteria:	pressure relief to protect bags from an excessive pressure surge and possible bag rupture
Operation plan:	
Study:	

+ Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. The 90 percent virus removal requirement can be waived, at the request of the supplier, under Section 64653 (g) if the supplier can, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

*The Department has been informed that 3M does not intend to continue providing the Model 523 product beyond December 31, 1999. This approval will be rescinded at that time, although existing systems may continue to operate until all cartridges have been used, or until December 31, 2001, whichever occurs first.

U.S. Filter, using their Model ELB-921 at Fern Valley Water District, has completed a demonstration of filtration effectiveness. The filtration technology tested consisted of a prefilter (Memtec 1 µm poly cartridge filter - Filterite "1U30U"), followed by a primary *Giardia* barrier (3M Model 523 bag filter with U.S. Filter Permaseal). The ELB 921 is a skid mounted unit containing the necessary piping, valves, cartridge and bag vessels, hydraulic instrumentation and controls, pumps, and turbidity sampling taps to constitute a complete filtration process.

The demonstration was conducted on a well protected low turbidity surface source at Fern Valley Water District, Idyllwild, California using a full size ELB-921. The source water turbidity ranged from 0.05 to 0.63 NTU during the study. The virus removal requirement was waived for this source per SWF&DR Section 64653(g). The demonstration was made using particle count and turbidity data. Performance of the filtration system is documented in a report entitled: Report on the Performance of the Model ELB-921 *Giardia* Removal Filtration System at Fern Valley Water District by Fern Valley Water District and U.S. Filter. The technology had previously been approved for use in Washington State on the basis of *Giardia* challenges (median 4.1 log removal).

The filtration system successfully demonstrated the ability to reliably achieve a 99% (2-log) *Giardia* cyst removal. This organism removal was achieved while an effluent turbidity of 0.2 NTU or less was observed in at least 95% of all measurements. It is not known whether the ELB-921 filtration system would meet the same organism removal efficiencies while producing a higher turbidity effluent.

The ELB-921 technology successfully demonstrated that it could achieve the required organism removals while reliably producing an effluent with a turbidity of 0.2 NTU. It is not known whether the ELB-921 filtration system would meet the same organism removal efficiencies while producing a higher turbidity effluent.

The design of an ELB-921 must include pressure relief to protect bags from an excessive pressure surge and possible bag rupture.

An operations plan for this filtration technology should address how loss of bag or seal integrity will be identified. An alarm triggered by a drop in headloss or high particle index is acceptable (both headloss and particle monitoring should be continuous). The plan must make it clear that the rinse of vessels at bag or cartridge change is done with treated water. The plan must identify the maximum flow through each cartridge and bag (not to exceed 50 gpm for the bag), and the maximum headloss across each cartridge and bag (not to exceed 30 psi for the bag). The plan must specify the triggers for cartridge and bag replacement and the replacement procedures. The plan shall identify the minimum supply of replacement cartridges and bags that will be maintained on site and justify this number in light of the anticipated rate of use and availability. A record must be kept of cartridge and bag purchases to be used to verify that they are not being reused.

A multi-media roughing filter is available for the ELB-921. This unit was not tested at Fern Valley because the source turbidities were consistently low. The ELB-921 could be approved on sources with turbidities in excess of one NTU if prefiltration were provided and operated to meet a one NTU performance standard. An existing non-complying filter plant may serve this purpose. The pre-filter cannot be expected to provide virus removal and this option is restricted to sources with limited virus contamination.

This U.S. Filter ELB-921 filtration system is an acceptable filtration technology for protected sources where the virus removal requirement can be waived and the turbidity is less than one NTU.

The Department has been informed that 3M does not intend to continue providing the Model 523 product beyond December 31, 1999. This approval will be rescinded at that time, although existing systems may continue to operate until all cartridges have been used, or until December 31, 2001, whichever occurs first.

8. Rosedale Bag Filtration System (Bob Hultquist)

Product: Company: Contact:	**Rosedale Bag Filtration System** Rosedale Products of California John Bush, (209) 683-6854
Technology:	two-stage bag system: prefilter (GD-PO-523-2), followed by a primary *Giardia* barrier (GLR-PO-82502), integrated into package plant, granular media prefilter as necessary
Study at:	Cactus CalTrans rest stop
By:	
Systems using:	
Raw Source:	Colorado R. Raw water up to 2 NTU (higher with prefiltration to 2 NTU)
Removal Credit:	2.0-log *Giardia*, 0-log virus removal[+]
Performance Std:	A = 0.2 NTU, to be met 95% of time, not to exceed 0.5 NTU
	B = 1.0, C = 0.5, D = 1.0, E = na
Operation criteria:	• head loss not to exceed 10 psi • up to 10 gpm per bag with prefilter • less than 3 gpm without prefilter
Design criteria:	• pressure relief to protect bags from an excessive pressure surge and possible bag rupture • filter to waste (FTW)
Operation plan:	gradually increase flow FTW each return to service - 5 min.
Study:	

[+] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. The 90 percent virus removal requirement can be waived, at the request of the supplier, under Section 64653 (g) if the supplier can, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

The filtration technology tested consisted of a prefilter (a GD-PO-523-2 nine layer polypropylene bag, supported by a stainless steel basked, in a 8-30-2F-2SP-150-N-S-N-FG-S-B-DP bag housing) followed by a primary *Giardia* barrier (a GLR-PO-82502-20+ layer polypropylene bag rigid outer shell supported by a stainless steel basket, in a 8-30-2F-2SP-150-N-S-NFG-S-GB-Dp bag housing). The Rosedale Bag Filtration System contains the necessary piping, valve, bag vessels, hydraulic instrumentation and controls, and turbidity sampling taps to constitute a complete filtration process.

The demonstration was conducted on a low turbidity surface source at Cal-Trans Cactus Reststop, California using a full size Rosedale Bag Filtration System. The source water turbidity ranged from 0.40 to 2.5 NTU during the study. The virus removal requirement was waived for this source per SWF&DR Section 64653 (g). The demonstration was made using particle count and turbidity data. Performance of the filtration system is

documented in a report entitled : Cal-Trans Cactus City Filtration Demonstration Study Results.

The filtration system successfully demonstrated the ability to reliably achieve 99% (2-log) *Giardia* cyst removal. This organism removal was achieved while an effluent turbidity of 0.2 NTU or less was observed in at least 95% of all measurements. It is not known whether the Rosedale Filtration System would meet the same organism removal efficiency while producing a higher turbidity effluent. Virus removal efficiency was not included in this study. The particle count data indicate a 90% (1-log) Cryptosporidium oocyst removal capability.

The prefilter was not used during all test runs and is not required for the organism removal credit. The prefilter is required only for high hydraulic loading rates (see subsequent discussion) and is desirable to extend the life of the *Giardia* barrier.

The appropriate permit provisions that addresses notification, Section 64663 (a & b), for this alternative technology, might read: "The supplier shall notify the Department within 24 hours by telephone whenever the turbidity of the combined filter effluent exceeds 1.0 NTU at any time."

To prevent possible bag rupture the installation of the Rosedale Bag Filtration System must include pressure relief to protect the *Giardia* barrier from a pressure surge that would cause a pressure differential across the bag in excess of 30 psi.

An operations plan for this filtration technology should address how loss of bag or seal integrity will be defined. An alarm triggered by a drop in headloss is acceptable (headloss monitoring should be continuous). The plan must make it clear that the rinse of vessels at bag change is done with treated water. The plan must identify the maximum flow through each *Giardia* barrier (not to exceed 3 gpm without a prefilter, 10 gpm with a prefilter bag) and the maximum operating headloss across each bag not to exceed 20 psi for the prefilter and 10 psi for the *Giardia* barrier. The plan shall identify the minimum supply of replacement bags that will be maintained on site and justify this number in light of the anticipated rate of use and availability. A record must be kept of bag purchases to be used to verify that they are not being reused. The system must filter to waste for five minutes upon startup of each new bag.

The Rosedale Bag Filtration System is effective for raw water turbidities up to two NTU. The Rosedale Bag Filtration System could be approved on sources with turbidities in excess of two NTU if additional prefiltration were provided and operated to meet a two NTU performance standard. An existing non-complying filter plant may serve this purpose. The additional prefiltration cannot be expected to provide virus removal.

The Rosedale Bag Filtration System is an acceptable filtration technology for protected sources where the virus removal requirement can be waived and the turbidity is less than 2.0 NTU.

9. 3M Cartridge Model #723A (Paul Gilbert-Snyder)

Product: Company: Contact:	**3M Cartridge Model 723A** 3M Filtration Products Jeffery Mitchell (800) 648-3550
Technology:	723A cartridge
Study at:	San Dimas Experimental Station
By:	Nat'l Park Service
Systems using:	Various National Parks: Bridge Campground, Lassen NF, Juanita Lake Campground, Klamath NF
Raw Source:	0.4 to 3.1 NTU with spikes to 10 NTU May be used on raw water with an average raw water turbidity of 3 NTU. Short duration (1 hour or less) spikes of 10 NTU or less are acceptable.
Removal Credit:	2-log *Giardia*, 0-log virus[+]
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B= 0.5, C= 0.2, D= 0.5
Operation criteria:	Not to be operated beyond 20 psid
Design criteria:	
Operation plan:	
Study:	

[+] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. The 90 percent virus removal requirement can be waived, at the request of the supplier, under Section 64653 (g) if the supplier can, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

Date of approval: June **, 1998 SWTR Committee Meeting minutes.

The United States Forest Service (USFS), in cooperation with R-P Products and the 3M Company, has completed a demonstration of filtration effectiveness to satisfy a requirement of the California Surface Water Filtration and Disinfection Regulation (CCR, Title 11, Chapter 17, Section 64650 et seq.) (SWF&DR), specifically Section 64653(f) dealing with alternative filtration technologies. The demonstration study was designed and conducted with Drinking Water Program participation and approval. The system evaluated was the **3M Model 723A Cartridge Filter with a stainless steel housing unit** provided by R-P Products. Acceptable housing unit model numbers are HE-SS4-F100-LP or HE-SS4-T-100-LP (A or D designations in the model number are irrelevant). The system contains the necessary piping, valve, container vessels, hydraulic instrumentation and controls, and turbidity sampling taps to constitute a complete filtration process.

The demonstration was conducted at the USFS Technology & Development Center in San Dimas, California. Seven filters were tested over a period of three months. The source water was domestic water with an artificially induced suspended solids load producing

average turbidities between 0.4 and 3.1 NTU. The system was also challenged with several short duration (1 hour or less) source water spikes of 10 NTU. Particle counters and turbidimeters were used to demonstrate removal of *Giardia* and *Cryptosporidium* sized particles, 5-15 µm and 2-5 µm, respectively. **The system was not tested for virus removal**.[4] Performance of the filtration system is documented in a report submitted to the Department with a cover letter dated March 25, 1998 (***provide reference***).

The system demonstrated the ability to reliably achieve 99% (2 log) removal of *Giardia* sized particles, while achieving effluent turbidities of 0.2 NTU or less. It is not known whether the system would provide the same removal efficiency while producing a higher turbidity effluent.

At differential pressures of 20 psi or less, the system demonstrated the ability to reliably achieve 99% (2 log) removal of *Cryptosporidium*-sized particles, while achieving effluent turbidities of 0.2 NTU or less. The test protocol was designed to demonstrate filter performance through 20 psid. Testing beyond psid was for reliability purposes only. If a supplier wishes to operate the filter at higher differential pressures an additional study will need to be completed. **(The manufacturer's literature suggests that these units can be operated up to a 35 psid. -Ed.)**

During a portion of the study, the source water experienced an algae bloom that affected system performance. Although 95th percentile removal of *Giardia*-sized particles remained at or above 2 log, the 95th percentile removal of *Cryptosporidium*-sized particles decreased to 1.8 log and the 95th percentile effluent turbidity increased to 0.23 NTU. Although *Giardia* removal requirements were met, the use of this system is not recommended for source waters that may experience algae blooms unless adequate pretreatment is provided. Such conditions may cause the effluent to exceed the 0.2 NTU performance standard and may also significantly shorten the cartridge life.

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[4] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. The 90 percent virus removal requirement can be waived, at the request of the supplier, under Section 64653 (g) if the supplier can, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed.

For systems serving 500 persons or less, alternative technologies are only required to demonstrate 90 percent *Giardia* removal. Since 3M has not demonstrated a minimum virus removal of 90 percent, this technology can only be used in:

1) systems that have demonstrated, through their sanitary survey, the lack of a virus hazard in the watershed, or

2) systems serving less than 500 persons.

A prefilter was not used during the study and is not required for the organism removal credit, although a prefilter would be recommended for higher solids (turbidity) loading rates (see subsequent discussion).

An operations plan for this filtration technology should address how loss of cartridge or seal integrity will be defined. An alarm triggered by a drop in headloss or high particle count is acceptable (headloss or particle monitoring should be continuous). The plan must make it clear that the rinse of vessels at cartridge change is done with treated water. The plan must identify the maximum flow through each cartridge, not to exceed 20 gpm, and the maximum operating headloss across each cartridge, not to exceed 20 psi. The system should be equipped with a feed back loop to ensure the differential pressure does not exceed 20 psi, and that the system will divert flow or shutoff if the differential pressure does exceed 20 psi. The plan shall identify the minimum supply of replacement cartridges that will be maintained on the site and justify this number in light of the anticipated rate of use and availability. **A record must be kept of cartridge purchases to be used to verify that they are not being reused**.

The 3M Model 723A is effective for raw water turbidities averaging up to 3 NTU, with short duration (1 hour or less) spikes of 10 NTU or less. The 3M Model 723A could be approved for use on sources with average turbidities in excess of 3 NTU if additional prefiltration were provided and operated to meet the 3 NTU performance standard. An existing non-complying filter may serve this purpose. The additional prefiltration cannot be expected to provide pathogen removal.

The Department has been informed that 3M does not intend to continue providing the Model 723A product beyond December 31, 1999 (Mitchell 1998). This approval will be rescinded at that time, although existing systems may continue to operate until all cartridges have been used, or until December 31, 2001, whichever occurs first.

The Department's SWTR committee concluded from the demonstration study results that the 3M Model 723A cartridge filter is an acceptable filtration technology for protected sources where the virus removal requirement can be waived and the turbidity is typically less than 3 NTU.

References

Mitchell, J.K.

Letter to Dr. David P. Spath, April 24, 1998.

3M Bag and Cartridge Filtration System

Product: Company: Contact:	**3M Bag and Cartridge Filtration** Filtration Technology Gregg Fisher (208) 336-6611
Technology:	523A bag and 744BW cartridge
Study at:	Sequoia Kings Canyon Nat'l Park Headquarters
By:	Nat'l Park Service
Systems using:	
Raw Source:	The turbidity ranged from 0.86 to 4.6 NTU. May be used on raw water up to 4 NTU (higher with prefiltration to 3 NTU)
Removal Credit:	1.5-log *Giardia* (see note under operating criteria), 0-log virus[+]
Performance Std:	A = 0.2 NTU, to be met 95% of time
	B= 0.5, C= 0.2, D= 0.5
Operation criteria:	suitable only for use by systems serving less than 500 persons Not to be operated beyond 20 psi (differential pressure?)
Design criteria:	pressure relief to protect bags from an excessive pressure surge (30 psi) and possible bag rupture
Operation plan:	
Study:	

[+] Under the current SWTR regulations, CCR Title 22 Chapter 17 Article 2 Section 64653 (f), alternative technologies must demonstrate that they can provide a minimum of 99 percent *Giardia* cyst removal and 90 percent virus removal to be used in systems serving more than 500 persons. The 90 percent virus removal requirement can be waived, at the request of the supplier, if the supplier can, through their watershed sanitary survey, demonstrate the lack of a virus hazard in the watershed. This technology also meets the minimum 1-log *Giardia* and 0-log virus removal requirements for systems serving less than 500 persons.

FOR SYSTEMS SERVING LESS THAN 500 PERSONS

Two 3M Systems were evaluated in the study. These systems were the 3M-Brand 523A bag filter with stainless steel housing unit and the 3M Brand 744BW Cartridge Filter with stainless steel housing unit. The 3M Company systems contains the necessary piping, valve, container vessels, hydraulic instrumentation and controls, and turbidity sampling taps to constitute a complete filtration process.

The demonstration was conducted on water from the Middle Fork of the Kaweah River, a low turbidity surface source, at the Sequoia Kings Canyon National Park Headquarters in Three Rivers, California. The source water turbidity ranged from 0.86 to 4.6 NTU during the study. The virus removal requirement was waived for this source per SWF&DR Section 65653(g) as proposed for revision. The *Giardia* cyst removal demonstration was made using particle count and turbidity data. Performance of the filtration system is

documented in a report submitted to the Department with a cover letter dated October 24, 1995.

The proposed revised Section 64653(g) would allow for use of alternative technology systems that can only achieve 90 percent *Giardia* cyst removal for systems serving less than 200 service connections. Both filtration systems successfully demonstrated the ability to reliably achieve 97 percent (1.5 log) *Giardia* cyst removal. This organism removal was achieved while an effluent turbidity of 0.2 NTU or less was observed in at least 95 percent of all measurements. It is not know whether the 3M Systems would provide the same organism removal efficiency while producing a higher turbidity effluent. Virus removal efficiency was not included in this study. The particle count data was not evaluated for Cryptosporidium oocyst removal capability.

A prefilter was not used during the study and is not required for the organism removal credit. A prefilter would be required for higher solids (turbidity) loading rates (see subsequent discussion) and is desirable to extend the life of the *Giardia* barrier.

To prevent possible bag rupture the installation of the 3M Systems must include pressure relief where necessary to protect the *Giardia* barrier from a pressure surge that would cause a pressure differential across the bag in excess of 30 PSI.

An operations plan for this filtration technology should address how loss of bag or seal integrity will be defined. An alarm triggered by a drop in headloss or high particle index is acceptable (Headloss or particle monitoring should be continuous). the plan must make it clear that the rinse of vessels at bag change is done with treated water. The plan must identify the maximum flow through each *Giardia* barrier (not to exceed 20 gpm for the 3M Bag (523A and 30 gpm for the 3M Brand 744W Cartridge filter) and the maximum operating headloss across each bag is not to exceed 30 psi for both systems. The plan shall identify the minimum supply of replacement bags or cartridges that will be maintained on site and justify this number in light of anticipated rate of use and availability. A record musts be kept of bag or cartridge purchases to be used to verify that they are not being reused. The system must filter to water for five minutes upon each startup.

The 3M Filtration Systems are effective for raw water turbidities up to 3.0 NTU. The 3M Filtration Systems could be approved on sources with turbidities in excess of 4.0 NTU if additional prefiltration were provided and operated to meet a 3.0 NTU performance standard. An existing non-complying filter plant may serve this purpose. The additional prefiltration cannot be expected to provide virus removal.

The Department's review committee concluded from the demonstration study results that the 3M Filtration Systems are an acceptable filtration technology for protected sources were the virus removal requirement can be waived and the turbidity is less than 3.0 NTU.

The Department has been informed (Mitchell 1998) that 3M does not intend to continue providing the Model 523A and 744BW products beyond December 31, 1999. This approval will be rescinded at that time, although existing systems may

continue to operate until all cartridges have been used, or until December 31, 2001, whichever occurs first.

References

Mitchell, J.K.

Letter to Dr. David P. Spath, April 24, 1998.

Questions regarding the policies contained in this report should be directed to the Surface Water Treatment Rule Committee. Corrections and additions should be sent to:

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Drinking Water Program
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Appendix A. First-Year Operation Reports

The Department recognizes that pilot-scale testing alternative filtration technologies provides

Section 64653(i) requires that:

> "Within 60 days following the first full year of operation of a new alternative filtration treatment process approved by the Department, the supplier shall submit an engineering report prepared by a qualified engineer describing the effectiveness of the plant operation. The report shall include results of all water quality tests performed and shall evaluate compliance with established performance standards under actual operating conditions. It shall also include an assessment of problems experienced, corrective actions needed, and a schedule for providing needed improvements."

The following first-year operational reports are known to have been submitted to the Department in fulfillment of the Section 64653(i) requirement.

Water system	Technology
San Jose Water Company and Metropolitan Water District of Southern California	Memcor Continuous Microfiltration System
East Bay Municipal Utility District, Pardee Recreation Area	Advent Membrane Systems, (Aquasource North America, LLC)
Marconi Conference Center	Desal DK5 Membrane: Memclear PC-2
Tracy Pumping Plant	Desal DK5 Membrane: Memclear PC-10
Casitas Municipal Water District	Sverdrup/Serck Baker Hi-Rate Pressure Filtration
Los Angeles Department of Water and Power PP1 and PP2 Water Treatment Plants	Culligan Duplex Multi-Tech Filter System Model MT-30D
Cactus City Rest Area operated by Caltrans	Rosedale Bag Filtration Plant
Castaic Lake Water Agency	Contact clarification and anthracite filtration
Paradise Irrigation District	Roberts Filter Company Contact Clarification Process
Calleguas Municipal Water District	High rate direct filtration plant using ozone for predisinfection

Memcor Continuous Microfiltration System

San Jose Water Company Saratoga Water Treatment Plant – Surface Water Treatment Rule Compliance Evaluation – August 30, 1994.

Performance and Operation Report of Memcor Microfiltration Units at Metropolitan Desert Pumping Plant dated April 25, 1995.

San Jose Water Company and Metropolitan Water District of Southern California

A summary of these reports will appear in a future edition of this report.

Advent Membrane Systems, (Aquasource North America, LLC)

East Bay MUD- Pardee Recreation Area Ultrafiltration Effectiveness

East Bay Municipal Utility District, Pardee Recreation Area

Ultrafiltration plant provided by Advent Membrane Systems, (Aquasource North America, LLC)

A summary of this report will appear in a future edition of this report.

Desal DK5 Membrane: Memclear PC-2 (Michael Finn and Richard Sakaji)

The following summary is based on a letter (dated October 5, 1998) from the Marconi Conference Center Treatment Plant Supervisor, Chris Hanson, submitted to the Department. The unit was installed in May 1995 and has never performed to their expectations (high operation and maintenance costs associated with frequent membrane cleaning and downtime) although the quality of water produced exceeds our requirements. They have experienced pressure switch and solenoid valve shutdowns for no apparent reasons. Instead of the anticipated manual dismantling and cleaning of the membranes every six months, the system is being cleaned every 2 weeks to keep it operational. The automatic backwash has not functioned properly as they do not switch back to production mode as designed. Although the influent flow and pressure to the unit are constant at 10 gpm and 35 psi, the filters have never produced treated water at the design flow of 5-8 gpm (actual production is 2-3 gpm). In addition, the installed Chem Trec PM 2500 particle monitor never operated as designed and the system is using daily manual turbidity checks to meet the permit requirements.

American Water Technologies, manufacturer of the Mem-Clear system, has apparently gone out of business. Efforts to contact this company have not been successful as the phone number in this report was disconnected with no forwarding number as of August 1998.

A county health official reported that a campground (Thousand Trails NACO, 4176 Yuba Gap, Emmigrant Gap, CA) using the Mem-Clear system had run into problems (frequent chemical cleaning required) with the operation of the membrane and called the Department inquiring about getting technical support. Since then a company by the name of Argo Scientific in San Marcos, CA (Mark Warren or Ray Eaton [760] 727-2620) took on the job of examining the membranes in an effort to determine if they could be salvaged by cleaning at the request of the Thousand Trails NACO corporate headquarters located in Dallas TX. (B.J. Thomas). Argo found that the membranes were only achieving about a 50% salt rejection and recommended they buy new membranes. In total about 20 membranes were evaluated by Argo for this one campground.

The membrane used in this system is manufactured by Osmonics DeSal.

Sverdrup/Serck Baker Hi-Rate Pressure Filtration

A summary of this report will appear in a future edition of this report.

Marion R. Walker Pressure Filtration Plant, Summary Report and Evaluation for the First Year of Operation. April 1998

High rate direct filtration plant using ozone for predisinfection.

Lake Bard Water Filtration Plant Alternative Filtration Technology One Year Report – October 1997.

Calleguas Municipal Water District

A summary of this technology will appear in a future edition of this report.

Contact clarification and anthracite filtration

Alternative Filtration Technology Engineering Report First year of operation – Rio Vista Treatment Plant – Castaic Lake Water Agency – November 1996.

Castaic Lake Water Agency

Contact clarification and anthracite filtration operating at 10 gallons per minute per square foot.

A summary of this technology will appear in a future edition of this report.

Microfloc contact clarifier and multi-media filtration.

West San Bernardino County Water District

Oliver P. Roemer Water Filtration Facility First Year Operations Report prepared by District staff, December 1996.

A summary of this technology will appear in a future edition of this report.

Roberts Filter Company Contact Clarification Process

Paradise Irrigation District Alternative Filtration Technology Report as Required by Section 64653(I) of the Surface Water Treatment Rule, November 1997.

Paradise Irrigation District

A summary of this technology will appear in a future edition of this report.

Culligan Duplex Multi-Tech Filter System Model MT-30D

Los Angeles Department of Water and Power PP1 and PP2 Water Treatment Plants

Culligan Package Treatment Plant which includes media clarification followed by multi media filtration and pressure vessels.

A summary of this technology will appear in a future edition of this report.

Rosedale Bag Filtration Plant

CalTrans-Cactus City Rest Area Water Treatment Plant Engineering Report – August 1997

Cactus City Rest Area operated by Caltrans

A summary of this technology will appear in a future edition of this report.

There is no evidence that the following systems and technologies have submitted their one year alternative technology operational reports.

Water System	Technology
Moose Lodge (Solano County)	Desal DK5 Membrane: Memclear PC-2
Hines Nursery (Solano County)	Desal DK5 Membrane: Memclear PC-2
Tracy Pumping Plant	Desal DK5 Membrane: Memclear PC-10
Yucaipa Valley Water District	EPD
Banning Heights Mutual	EPD
Miners Oaks CWD	EPD
Havasu WC	EPD

At this time a central list of alternative treatment technologies does not exist. Efforts are underway to create such a list and it is hoped that the next edition of this report will contain the information.

Corrections and additions to this section should be sent to:

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Appendix B. Studies

A. Studies Underway

Olivenhein Water District

B. Studies anticipated

The following studies and product evaluations for alternative filtration devices are currently underway:

Olivenhein Water District – Study protocol approved, study in progress, action pending

Koch Membrane Systems-Manufacturer submitted data from other studies, Department completed review and comments, Reponse to comments currently under review.

Harmsco-Product presentation, limited data submitted, but no study protocol submitted for Department consideration, may be testing under the U.S. Forest Service protocol approved for USFS San Dimas Testing Facility.

Kinetico-General protocol received and reviewed by the Department-further protocol review will not be taken until a test site is identified.